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Optimisation of Thermal Energy Storage integration in a residential heating system

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Despite the significant share of heat demand in the UK energy consumption, the management and storage of thermal energy have been overlooked relative to its electrical counterpart [1]. However, Thermal Energy Storage (TES) is one of the key technologies to enable more efficient heating systems and the decarbonisation of the heating sector. The domestic sector is one of the major consumers of heat and as such the integration of TES in domestic heating systems offers a large potential for efficiency improvement and CO₂ emissions mitigation. However, the inclusion of TES provides a new set of challenges in the design and operation of the heating systems as well as in the integration in the wider energy system through future smart grids. These include the large variability of energy supply, flexibility and reliability issues, and trade-offs in demand-side management actions. For example, a careful sizing and operational optimisation are required in order to ensure improvement (cost and/or CO₂ emissions) relative to the traditional heating system. This is particularly important if the integration into the wider energy system is considered.

This study presents the design and operational optimisation of an integrated heating system consisting of an Air Source Heat Pump coupled with TES for the domestic sector. The TES allows the shifting of heating demand to periods of lower electricity prices or in the future to periods with surplus renewable electricity in the grid. The optimisation procedure is applied to test cases for different building types and occupancy profiles. For each test case the heat demand is generated based on the outside temperature, dwelling characteristics and time-use data. While the winter peak demand is crucial for the sizing of the heating system, the performance over the year determines the heating costs. The optimisation takes this into account by using several demand profiles which are representative of the winter peak demand as well as of the demand in the other seasons. The resulting heating system satisfies the winter demand while minimising the heating costs. The running costs of this system are compared to a conventional heating system for different electricity prices.

1. Institution of Mechanical Engineers. (2014). Energy Storage: The Missing Link in The UK's Energy Commitments. Available online at: <http://www.imeche.org/knowledge/themes/energy/energy-storage>. (Last accessed: 26 August 2014)